This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

FIRST GRADE.

PRACTICAL GEOMETRY.

BY

DAVID BAIN, F.R.G.S.

LONDON:
GEORGE PHILIP & SON, 32, FLEET STREET;
LIVERPOOL: CAXTON BUILDINGS, SOUTH JOHN STREET,
AND 49 & 51, SOUTH CASTLE STREET.
1879.

PRICE THREEPENCE.

600047130L

1037. e. 67

FIRST GRADE.

PRACTICAL GEOMETRY.

BY

DAVID BAIN, F.R.G.S.

LONDON:
GEORGE PHILIP & SON, 32 FLEET STREET;
LIVERPOOL: CAXTON BUILDINGS, SOUTH JOHN STREET,
AND 49 & 51 SOUTH CASTLE STREET.
1879.

PRINTED BY G. PHILIP AND SON, LIVERPOOL.

BIBLIOTHECA BODLEIANA

PREFACE.

THE aim of the present little work is to supply the youthful student with the fundamental principles of Practical Geometry. It is designed to meet the wants of the latest Syllabus of the First-Grade Examinations of the Science and Art Department. So far as the Author is aware, there exists no text-book which exactly covers the work of the most recent requirements of that Syllabus.

In taking their pupils through the book, teachers are advised to attempt the Test Exercises, only on going over the problems a second time. Too much use of the black board cannot be made, while neatness as well as accuracy cannot be too strongly insisted upon.

To those who have mastered the problems there should be little or no difficulty in copying the Figures at the end.

The Papers set by the Department in the March Examinations (1877–8–9) will be useful for examination purposes, and will also furnish teachers and pupils with a good idea of what is expected from them by the Department.

D. B.

ST. BRIDE'S SCHOOLS,
LIVERPOOL, *June* 1879.

INSTRUCTIONS AND REQUIREMENTS

IN

FIRST-GRADE GEOMETRY.

(*From the most Recent Edition of the "Art Directory,"* 1879.)

"THE instruments * required are a plain scale of inches divided into eighths, a pair of dividers, a pair of pencil compasses, two set squares, an H. pencil, and a piece of india-rubber; a drawing board and T square, although not indispensable, are very desirable.

"This stage is intended to teach elementary notions of Practical Geometry, and the use of simple drawing instruments.

"The pupil should be taught to draw clean, join lines passing fairly through indicated points, and the greatest care should be exercised to prevent the formation of slovenly habits, such as using both hands to the dividers, forcing their points into the paper, &c. He should then be shown how to take given distances from the scale, and step them along a given line, and he should be practised in the use of set squares for drawing lines parallel and perpendicular to each other.

"By the help of the black board the teacher should explain and define an angle, a triangle, a square, a rectangle, a circle, &c. The pupil may then be practised in such simple exercises as the following:—Construct a square or rectangle, the lengths of the sides being given in inches and eighths. Divide them when drawn into a given number of equal parts. An irregular four-sided figure is roughly sketched on the black board; the dimensions of its sides and diagonals are given. Draw the figure its proper size. Neatness and accuracy should be insisted upon, and, if unsatisfactory in these respects, the figures should be re-drawn. It is desirable to accustom the pupil to the erasure of superfluous lines or portions of lines, and to the employment of 'dotted' or 'chain-dotted' lines and arcs to distinguish lines drawn for constructional purposes.

"The examination will be confined to examples in the following constructions, and equal value will be attached to neat drawing and to geometrical accuracy:—

"1. The division of a given line into a given number of equal parts by trial with the dividers, and also by construction.

"2. To draw lines parallel and perpendicular to given lines by means of the set squares, and also by construction.

"3. To construct an equilateral triangle and a square of given sides.

"4. To construct an angle equal to a given angle.

"5. To bisect a given angle.

"6. To construct a triangle, given the sides, or sides and angles.

"7. To construct a triangle similar to a given triangle and standing on a given base.

"8. To describe two circles of given radii touching each other."

---

* The instruments really essential for this subject are:—

(1.) A six-inch flat ruler, divided into inches and eighths.
(2.) A pair of pencil compasses.
(3.) An H. or H.B. pencil.
(4.) A piece of india-rubber.

BAIN'S

FIRST GRADE PRACTICAL GEOMETRY.

DEFINITIONS.

(To be thoroughly mastered before proceeding further.)

1. **A Point** has position only; it has no magnitude.

The smallest dot we can make, as A, must have some size, but mathematically speaking, the point is not the whole dot, but only its centre. A•

LINES.

NOTE.—Lines have length or direction, but no breadth or thickness. The finest line that can be drawn must have thickness, and is therefore not a true geometrical line, but for convenience it is called such.

2. **A Straight Line** is the shortest distance between two points.

3. **A Curved Line** is nowhere straight, and continually changes its direction.

Fig. 2.

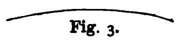


Fig. 3.

DIRECTION OF LINES.

4. **A Horizontal Line** is perfectly level, and runs right and left.

5. **A Vertical Line** is perfectly upright.

6. **An Oblique Line** is one neither horizontal nor vertical.

7. **Parallel Lines** are the same distance apart throughout their entire length, and on being produced ever so far never meet.

Fig. 4.

Fig. 5.

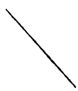


Fig. 6.

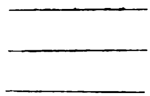


Fig. 7.

ANGLES.

8. **An Angle** is the inclination of two straight lines which meet in a point.

There are three kinds of angles—right angles, acute angles, and obtuse angles.

9. Right Angles.—When one straight line, as A B, falls on another straight line, as C D, such that the two angles A B C, A B D, are equal, the lines are perpendicular to each other, and each of the equal angles is called a right angle.

10. An Obtuse Angle is one greater than a right angle.

11. An Acute Angle is one less than a right angle.

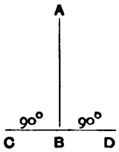


Fig. 9.

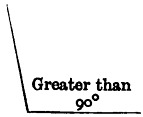


Fig. 10.

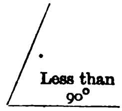


Fig. 11.

TRIANGLES.

12. Triangles are figures bounded by three straight lines, and consequently have three angles.

There are six kinds of triangles—three being named from the comparative lengths of their sides, viz., equilateral, isosceles, and scalene triangles; and three from the size of their angles, viz., right-angled, obtuse-angled, and acute-angled triangles.

13. An Equilateral Triangle has three equal sides.

14. An Isosceles Triangle has two sides equal.

15. A Scalene Triangle has all its sides unequal.

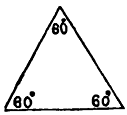


Fig. 13.

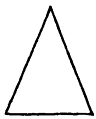


Fig. 14.

Fig. 15.

16. A Right-Angled Triangle has one angle a right angle. The side opposite the right angle is called the hypotenuse.

17. An Obtuse-Angled Triangle has one of its angles an obtuse angle.

18. An Acute-Angled Triangle has its three angles acute.

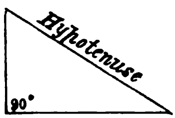


Fig. 16.

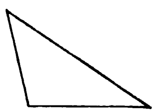


Fig. 17.

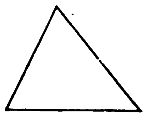


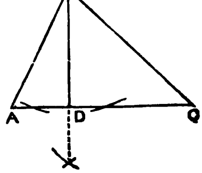
Fig. 18.

IMPORTANT OBSERVATIONS.

(*a.*) Any two sides of a triangle are, when added together, greater than the third side.

(*b.*) The three angles of any triangle, when added together, equal two right angles, or 180 degrees (written 180°). If two angles of a triangle are known to be 45° and 60° respectively, the remaining angle will be 75°. Thus 45° added to 60° equal 105°, which, taken from 180°, leaves the remaining angle 75°.

(*c.*) The highest angle of a triangle, as the angle at B of the triangle A B C, is called the vertex, or apex, or vertical angle. The lowest side, as A C, is called the base. The altitude or height of a triangle is the perpendicular drawn from the apex to the base, as B D.



QUADRILATERAL (FOUR-SIDED) FIGURES.

Quadrilateral figures are bounded by four sides, and are sometimes called quadrangles, because they have four angles. The four angles of any quadrilateral figure always equal 360°, or four right angles.

19. A Parallelogram is a four-sided figure having its opposite sides equal and parallel.

There are four kinds of parallelograms—square, rectangle, or oblong, rhombus, and rhomboid.

20. A Square is a four-sided figure, having all its sides equal and all its angles right angles.

21. A Rectangle, or Oblong, is a four-sided figure, having only its opposite sides equal, but all its angles right angles.

The *diagonal* of a figure is the straight line joining opposite angles, as AB.

22. A Rhombus is a four-sided figure, having all its sides equal but none of its angles right angles.

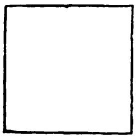


Fig. 20.

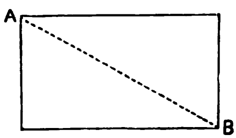


Fig. 21.

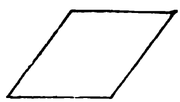


Fig. 22.

23. A Rhomboid is a four-sided figure, having only its opposite sides and angles equal.

24. A Trapezium is a four-sided figure, having none of its sides parallel.

25. A Trapezoid is a four-sided figure, having only two of its sides parallel, but some of its sides or angles may, or may not, be equal.

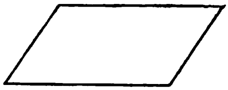


Fig. 23.

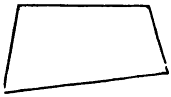


Fig. 24.

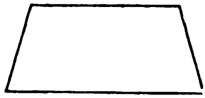


Fig. 25.

THE CIRCLE.

26. A Circle is a figure bounded by a continuous curved line, called the circumference, every part of which is equally distant from a fixed point within, called the centre.

27. A Radius (plural *radii*) is any straight line drawn from the centre to the circumference.

28. A Diameter of a circle is a straight line drawn through the centre, and terminated at both ends by the circumference.

The diameter, which is equal to twice the radius, divides the circle into two equal parts, each of which is called a semicircle.

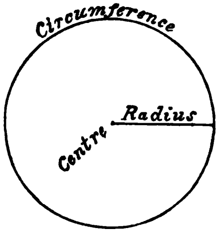


Fig. 26, 27.

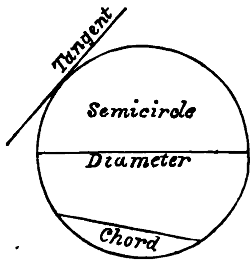


Fig. 28, 29, 30.

29. A Tangent is a straight line which touches the circumference of a circle in a point, but does not cut the circumference.

30. A Chord is any straight line drawn across a circle, but which does not pass through the centre.

31. An Arc is any part only of the circumference of a circle.

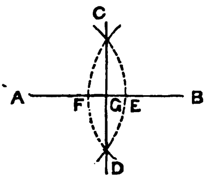
SECTION I.

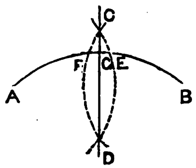
LINES AND ANGLES.

(In copying these problems pupils should make the diagrams at least double the size of those printed.)

Problem 1.—*To bisect, that is, to divide into two equal parts, a given straight or curved line,* A B.

1. With A as centre and the distance or radius A E, which must be greater than half A B, describe the arc C E D.

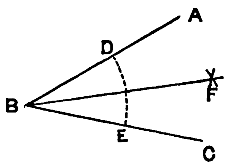




2. With B as centre, and the same radius, describe the arc C F D, cutting the first arc at points C and D.
3. Draw the straight line C D which bisects A B in the point G.

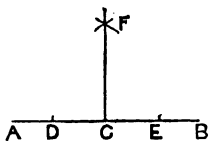
Problem 2.—*To bisect any given angle* A B C, *that is, to divide it into two equal angles.*

1. With B as centre, describe any arc D E.
2. With D and E as centres, describe arcs cutting in F.
3. Draw the line B F which bisects the angle A B C.

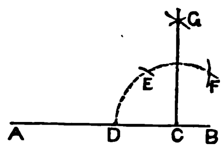


Problem 3.—*To draw a straight line perpendicular, that is, at right angles, to a given line* A B, *from a given point* C *in the line.*

1. With C as centre and any suitable radius cut A B in D and E.
2. With D and E as centres draw arcs cutting in F.
3. Draw line F C which is perpendicular, or at right angles, to A B.

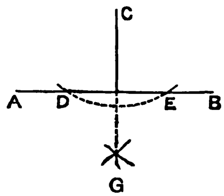


Problem 4.—*To draw a straight line perpendicular, that is, at right angles to a given line* A B, *from a given point* C, *at or near the end of the line.*

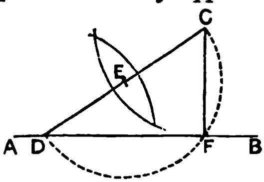
1. With C as centre and any suitable radius describe the arc D E F, having its end D in the line A B.
2. With D as centre and the same radius describe the arc E: and with E as centre and the same radius describe the arc F.
3. With centres E and F and still same radius describe arcs cutting in G.


4. Draw the line C G which is perpendicular to A B.

Problem 5.—*To draw a straight line perpendicular to a given straight line from a given point* C, *above or below the line.* (*Let the point be above the line* A B.)

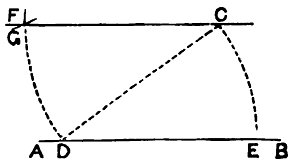
1. With C as centre and any suitable radius describe an arc cutting A B in the points D and E.
2. With points D and E as centres and any convenient radius describe arcs cutting in G.
3. Draw the line C G which is perpendicular to A B.


Another Method.—*When* C *is opposite or nearly opposite the end of* A B.

1. In A B take any point D not opposite C.
2. Draw the line C D and bisect it in E (Problem 1).
3. With E as centre and E C as radius describe the semicircle C F D cutting A B in F.


4. Draw the line C F which is perpendicular to A B.

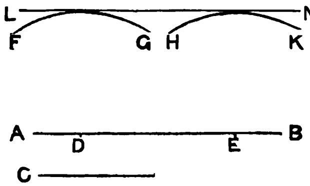
Problem 6.—*Through a given point* C, *to draw a line parallel to a given line* A B.

1. In A B take any point D not opposite C.
2. Join C D.
3. With D as centre and radius D C describe the arc C E.
4. With the same radius and C as centre describe the arc D F.
5. With D as centre and radius E C describe an arc cutting D F in G.


6. Join C G which will be parallel to A B.

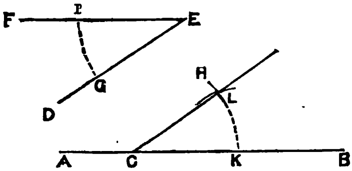
Problem 7.—*To draw a line parallel to a given line* A B *at a given distance, equal to* C, *from it.*

1. In A B take any two points, D and E, and with these as centres and radius C draw the arcs F G and H K.
2. Draw the line L M touching these arcs: L M is parallel to A B and drawn from it at a distance equal to the given line C.



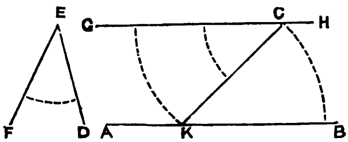
Problem 8.—*From a given point* C, *in a given line* A B, *to make an angle equal to a given angle* D E F.

1. With E as centre and any convenient radius, describe the arc I G.
2. With C as centre and the same radius describe the arc K H cutting A B in K.
3. With K as centre and radius G I describe an arc cutting K H in L.
4. Draw C L, which with A B makes an angle L C B equal to the given angle D E F.



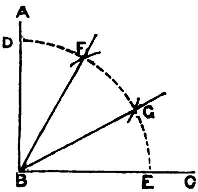
Problem 9.—*From a given point* C, *outside a given line* A B, *to draw a line, making with the given line an angle equal to a given angle* D E F.

1. Through the point C draw G H parallel to A B (Problem 6).
2. At the point C draw a line C K making with G H an angle G C K equal to D E F (Problem 8).
3. The angle C K B will also be equal to D E F.



Problem 10.—*To trisect a right angle* A B C, *that is, to divide it into three equal angles.*

1. With centre B and any convenient radius draw the arc D E.
2. With the same radius and D and E as centres draw arcs cutting D E in G and F.
3. Join B F and B G. These lines will trisect the right angle (90°) into three equal angles (each 30°).



TEST EXERCISES ON THE PRECEDING PROBLEMS.

1. Divide a given straight line into four equal parts.
2. Draw a vertical line 2½ inches long. From the upper extremity draw a line A C 2 inches long, and at right angles to A B. Bisect the angle B A C.
3. Draw two lines parallel to a given line A B, one above and one below, at a distance of one inch from it.
4. A B is a horizontal line 2 inches long. Bisect it, and at the point of bisection, C, erect a perpendicular, C D, 1½ inches long. Divide the angle D C A into four, and the angle D C B into three equal angles.
5. At one end of a straight line make an angle equal to a given angle, and at the other end make an angle double the size of the given angle.
6. Divide a given right angle into six equal angles. How many degrees will be in each of these six angles?

SECTION II.

LINES, ANGLES, AND TRIANGLES.

Problem 11.—*To construct angles of a given number of degrees, such as* 60°, 30°, 15°, 45°, 75°, *and* 120°.

(1.) At point A in the line A B to make an angle of 60°.

1. **With A as centre and any convenient radius describe the arc C D.**
2. **With D as centre and the same radius describe an arc cutting D C in E.**
3. **Draw line A E. The angle B A E equals 60°.**

(2.) At point A make an angle of 30°.

1. **With A as centre and any convenient radius describe the arc B C.**
2. **With centre B and same radius describe the arc A C D.**
3. **With centre C and same radius draw arc B E.**
4. **Join A E. The angle E A B equals 30°.**

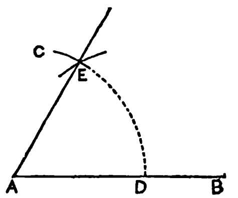


Fig. 1.

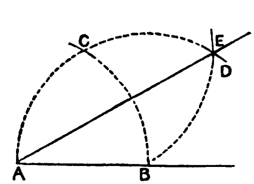


Fig. 2.

(3.) At point A make an angle of 15°.

1. **As in the last case (2) construct an angle E A B of 30°.**
2. **With centres, F and B and any suitable radius describe arcs cutting in G.**
3. **Join A G. The angle G A B equals 15°.**

(4.) At point A make an angle of 45°.
1. As in the last case (3) obtain the points B C D E and F.
2. With C and F as centres describe arcs cutting in G.
3. Join A G. The angle G A B equals 45°.

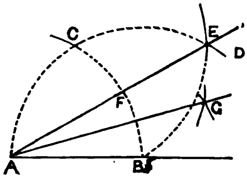


Fig. 3.

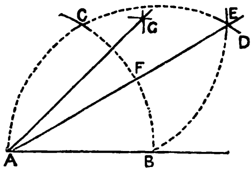


Fig. 4.

(5.) At point A make an angle of 75°.
1. As in the last case (4) obtain points B C D E F and G.
2. From C as centre mark off C H equal to C I.
3. Join H A. The angle H A B equals 75°.

(6.) At point A make an angle of 120°.
1. With A as centre and any convenient radius describe the arc B D C.
2. With centre B and same radius describe the arc A D, and with centre D and still same radius describe arc A E.
3. Join A E. The angle E A B equals 120°.

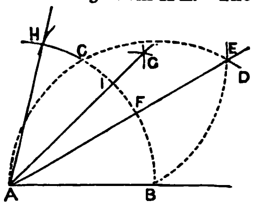


Fig. 5.

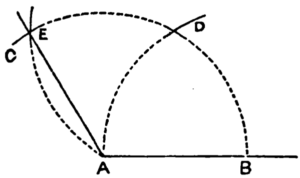
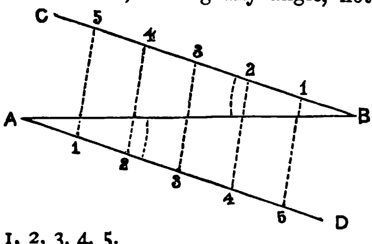


Fig. 6.

Problem 12.—*To divide a straight line,* A B, *into any number of equal parts; say six equal parts.*

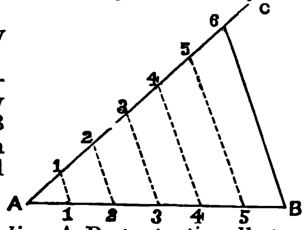
First Method.—1. Draw the line B C, making any angle, not too great, with A B.



2. At point A draw A D making the angle B A D equal to A B C (Problem 8).
3. From B mark off on B C a number of spaces (of any suitable and *equal* length) equal to the number, less one, into which A B is to be divided, as 1, 2, 3, 4, 5.
4. From A mark off on A D five *similar* spaces.
5. Join 5 1, 4 2, 3 3, 2 4, and 1 5. These lines divide A B into six equal parts.

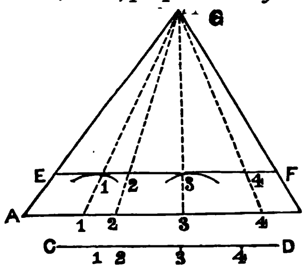
Second Method.—1. Draw the line A C making with A B any convenient angle C A B.

2. From A mark off on A C any six *equal* spaces, 1, 2, &c.
3. Join 6 B, and through the remaining divisions on A C draw lines to A B but parallel to 6 B (Problem 9). The points in which these lines meet A B will divide it into 6 equal parts.



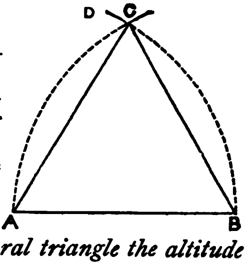
Problem 13.—*To divide a given line,* A B, *proportionally to a given divided line* C D.

1. Draw E F equal to C D and parallel to A B.
2. Mark off the divisions 1, 2, 3, 4 from C D on to E F.
3. Join A E and B F, producing these lines till they meet in G.
4. From G draw lines through the divisions 1, 2, 3, 4, on E F till they meet A B. The points in which these lines meet A B divide it proportionally to C D.



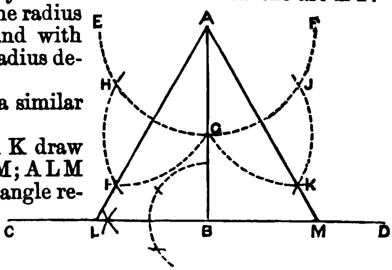
Problem 14.—*On a given straight line,* A B, *to construct an equilateral triangle.*

1. With centre A and radius A B describe arc B D.
2. With centre B and same radius describe arc A C cutting the former arc in C.
3. Join A C and B C. The triangle A B C is equilateral and is constructed on A B.



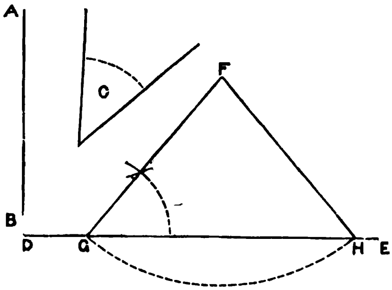
Problem 15.—*To construct an equilateral triangle the altitude or height,* A B, *being given.*

1. Through B draw the line C D perpendicular to A B (Problem 4).
2. With centre A and any convenient radius draw the arc E F.
3. With centre G and same radius describe arc H I, and with centre H and same radius describe arc G I.
4. Obtain the point K in a similar manner.
5. Through points I and K draw the lines A L and A M; A L M is the equilateral triangle required.



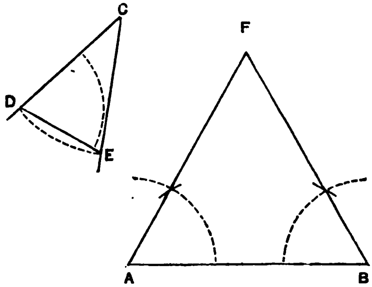
Problem 16.—*To construct an isosceles triangle, one of the equal sides* A B, *and one of the equal angles* C, *being given.*

1. Draw any line D E of indefinite length.
2. Make the angle E G F equal to the angle C (Problem 8), and make G F equal to A B.
3. With centre F and radius F G describe the arc G H.
4. Join F H. G F H is the required isosceles triangle, having two sides equal to A B and two angles equal to C.



Problem 17.—*To construct an isosceles triangle, the base* A B *and the angle at the apex* C, *being given.*

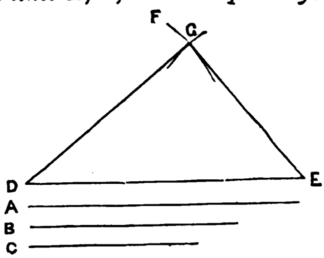
1. With C as centre and any suitable radius describe the arc D E.
2. Join D E.
3. Make each of the angles at A and B equal to the angle C D E (Problem 8).
4. Produce the two lines A F and B F till they meet in F. F A B is the required isosceles triangle, having an angle F, at the apex equal to the given angle C, and it is constructed on the given base A B.



The reasoning of this problem follows from Observation (*b*), Definitions.

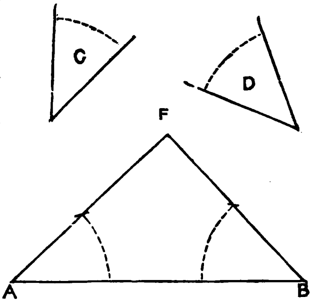
Problem 18.—*To construct a triangle, each of the sides of which shall be equal to three given lines* A, B, *and* C *respectively.*

1. Draw D E equal to A.
2. With D as centre and B as radius describe the arc F.
3. With E as centre and C as radius describe an arc cutting F in G.
4. Draw lines D G and E G. D E G is the triangle required.



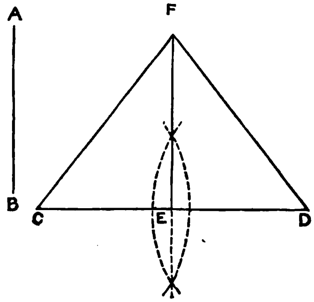
Problem 19.—*To construct a triangle, the base* A B *and the angles* C *and* D *at the base being given.*

1. Make the angle B A F equal to the angle C (Problem 8).
2. Make the angle A B F equal to the angle D (Problem 8).
3. Produce the line A F and B F till they meet in F. F A B is the triangle required.



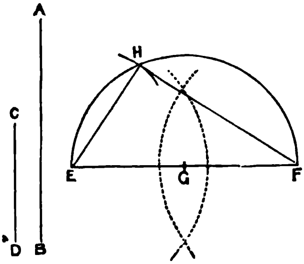
Problem 20.—*To construct an isosceles triangle, the altitude* A B *and the base* C D *being given.*

1. Bisect C D in E (Problem 1) by the perpendicular E F, which make equal to A B.
2. Join C F and D F. F C D is the required isosceles triangle.

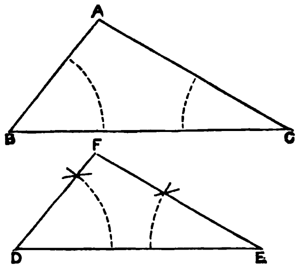


Problem 21.—*To construct a right-angled triangle having given the hypotenuse* A B *and one of the other sides* C D.

1. Draw the straight line E F equal to A B.
2. Bisect E F in the point G (Problem 1).
3. With G as centre and radius G E describe the semicircle.
4. With E as centre and radius C D draw an arc cutting the semicircle in H.
5. Join E H and H F. H E F is the triangle required, having the right angle E H F.



Problem 22.—*On a given base* D E *to construct a triangle* similar *to the given triangle* A B C.



1. At the point D make an angle F D E equal to the angle A B C (Problem 8).
2. At E draw the line E F making the angle F E D equal to the angle A C B (Problem 8).
3. Produce D F and E F till they meet in F. The triangle F D E is *similar* to A B C, that is, it has angles equal to the angles in the triangle A B C, each to each.

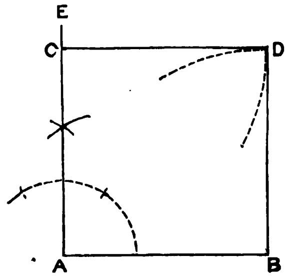
TEST EXERCISES ON THE PRECEDING PROBLEMS.

1. On A B as base construct a triangle having an angle at A 60°, and another at B 45°. How many degrees will be in the remaining angle?
2. At a point C in a given straight line A B draw a line making with the given line an angle of 75°.
3. Construct an isosceles triangle having equal sides of two inches each, and the angle opposite the base 30°.
4. Divide a given line A B into seven equal parts, and on three of these parts, as base, describe an equilateral triangle.
5. Describe an equilateral triangle whose altitude shall be $2\frac{1}{2}$ inches.
6. Construct a triangle whose sides are 2 inches, $1\frac{1}{2}$ inches, and $2\frac{1}{4}$ inches in length respectively.
7. Draw a line A B ($2\frac{1}{2}$ inches). Find a point C which shall be 2 inches from this line, and equidistant from the ends of A B.
8. On a given base construct a triangle similar to a given triangle.

SECTION III.

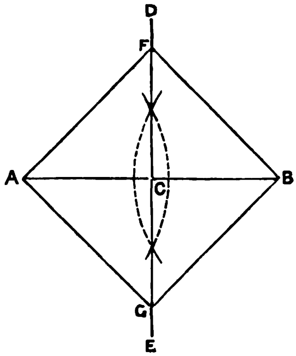
QUADRILATERAL OR FOUR-SIDED FIGURES.

Problem 23.—*On a given line* A B *to construct a square.*



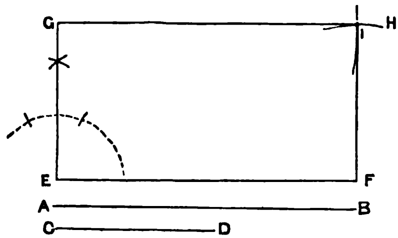
1. At A draw A E perpendicular to A B (Problem 4).
2. Make A C equal to A B.
3. With centres B and C and radii A B draw arcs intersecting in D.
4. Join C D and B D. A B D C is the square required.

Problem 24.— *To construct a square of which the diagonal* A B *is given.*



1. Bisect A B in C by the perpendicular D E (Problem 1).
2. With C as centre and C A as radius cut off C F and C G.
3. Join A F, F B, B G, and G A. A G B F is the square required, having A B as diagonal.

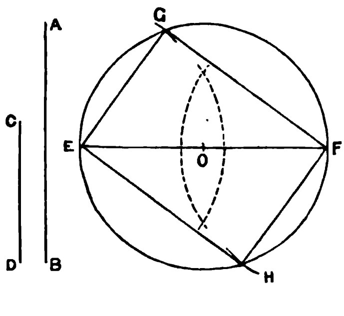
Problem 25.—*To construct an oblong or rectangle, the lengths of the two adjacent sides,* A B *and* C D, *being given.*



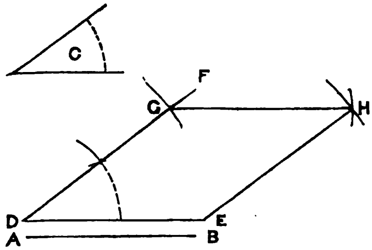
1. Make E F equal to A B.
2. At E make the perpendicular E G equal to C D (Problem 4).
3. With F as centre and radius C D draw the arc H, and with G as centre and radius A B draw arc cutting H in I.
4. Join G I and F I. E G I F is the oblong required, having its adjacent sides equal to the two lines A B and C D.

Problem 26.—*To construct an oblong of which the diagonal* A B, *and one of the sides* C D, *are given.*

1. Make E F equal to A B.
2. Bisect E F in point O (Problem 1).
3. With O as centre and radius O E describe the circle.
4. With E and F as centres and radii C D describe the arcs cutting the circle in G and H.
5. Join E G, G F, F H, and H E. E G F H is the required oblong.

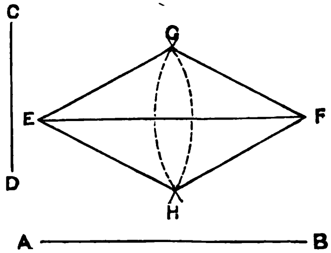


Problem 27.—*To construct a rhombus, having given one of the sides* A B *and one of the angles* C.



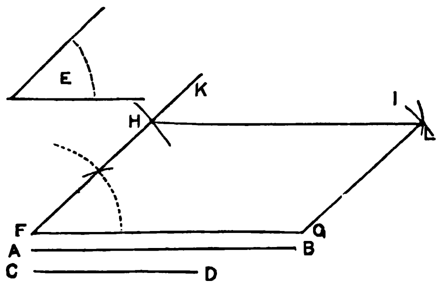
1. Make D E equal to A B.
2. Make angle E D F equal to C.
3. Cut off D G equal to D E.
4. With centres G and E and radii A B describe arcs cutting in H.
5. Join G H and E H. D G H E is the rhombus required.

Problem 28.—*To construct a rhombus, the diagonal* A B *and one of the sides* C D *being given.*



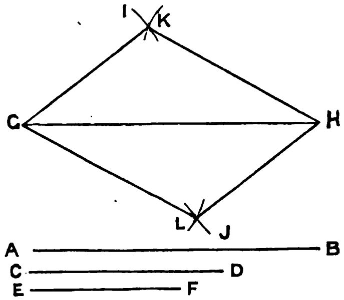
1. Make E F equal to A B.
2. With centres E and F and radii C D describe arcs cutting in G and H.
3. Join E G, G F, F H, and H E. E G F H is the rhombus required.

Problem 29.—*To construct a rhomboid of which* A B *and* C D *are equal to two adjacent sides and* E *equal to one of the angles.*



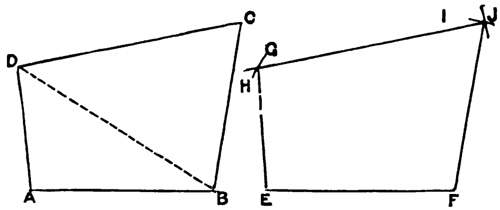
1. Make F G equal to A B.
2. At F make the angle K F G equal to E. Make F H equal to C D.
3. With centre H and radius A B describe the arc I.
4. With centre G and radius C D describe arc cutting I in L.
5. Join H L and L G. F G L H is the rhomboid required.

Problem 30.—*To construct a rhomboid of which the diagonal* A B *and the two adjacent sides* C D *and* E F *are given.*



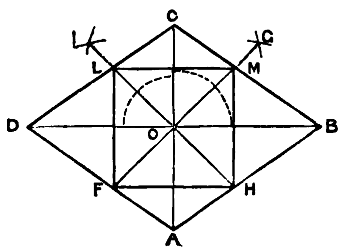
1. Make G H equal to A B.
2. With centres G and H and radii E F make arcs I and J.
3. With the same centres and C D as radii make arcs cutting the former arcs in K and L.
4. Join G K, K H, H L, and L G. G K H L is the required rhomboid.

Problem 31.—*To construct a trapezium similar and equal to a given trapezium* A B C D.



1. Make E F equal to A B.
2. With centre F and radius B D describe the arc G.
3. With centre E and radius A D describe an arc cutting G in H.
4. With F as centre and radius B C describe the arc I, and with centre H and radius D C make an arc cutting I in J.
5. Join E H, H J, and F J. E H J F is a trapezium similar and equal to A B C D.

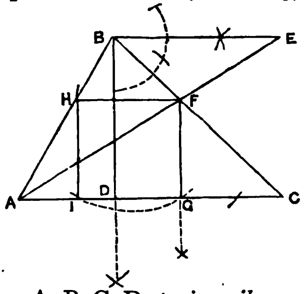
Problem 32.—*To inscribe a square within any rhombus* A B C D.



1. Draw the diagonals A C D B.
2. Bisect the two angles C O D and C O B by the lines H I and F G (Problem 2).
3. Join L M, M H, H F, and F L. L F H M is the square inscribed in the given rhombus A B C D.

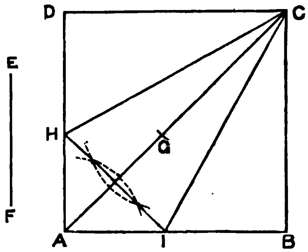
Problem 33.—*To inscribe a square in a given triangle* A B C.

1. From the point B draw B D perpendicular to A C (Problem 5).
2. From B draw B E equal to B D and at right angles to it (Problem 4).
3. Join E A, cutting B C in F, and from F draw F G perpendicular to A C. (Problem 5).
4. With F and G as centres and F G as radii draw the arcs H and I.
5. Join I H and H F. I H F G is the required square.



Problem 34.—*In a given square* A B C D *to inscribe an isosceles triangle of base equal to* E F, *such that the two equal angles of the triangle shall touch two adjacent sides of the square.*

1. Draw the diagonal C A.
2. From A C cut off A G equal to E F.
3. Bisect A G by the perpendicular H I meeting A D and A B in the points H and I.
4. Join C H and C I. C H I is the triangle required.



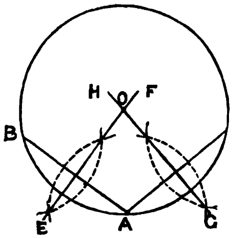
TEST EXERCISES ON THE PRECEDING PROBLEMS.

1. Divide a given square into four equal squares.
2. Draw a horizontal line $1\frac{1}{2}$ inches long; with this line as diagonal construct a square.
3. Construct an oblong the longer sides of which shall be $2\frac{1}{4}$ inches, and the shorter half that length.
4. Divide a line A B (3 inches long) into seven equal parts. Taking five of these parts as a diagonal construct a rhombus, the sides of which shall each equal three parts of the divided line.
5. On a given line construct an equilateral triangle; and on each side of the triangle construct a square.
6. A B is a line 1 inch in length. Construct a rhombus, taking this line as one of the sides, and let the angle at B be 120°.
7. Inscribe an equilateral triangle in a given square, such that two angles shall touch adjacent sides of the square (Problem 15).
8. On A B as diagonal construct a square, which divide into four equal squares.

SECTION IV.

THE CIRCLE.

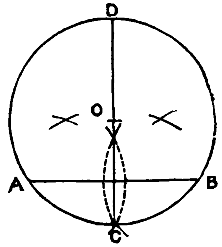
Problem 35.—*To find the centre of a given circle.*



First Method.—1. From any point A, in the circumference, draw two chords A B, A C.

2. Bisect these chords by perpendiculars E F, G H, intersecting in O (Problem 1). O is the centre of the circle.

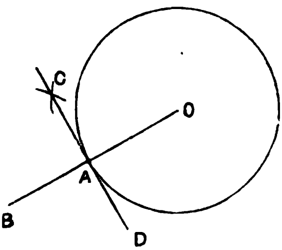
NOTE.—In this way the centre from which part of a circle is drawn may be found.



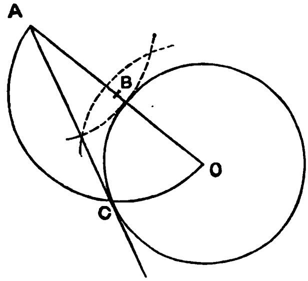
Second Method.—1. Draw any chord A B.
2. Bisect A B by the perpendicular C D (Problem 1), which is a diameter.
3. Again, bisect C D in the point O (Problem 1). O is the centre of the circle.

Problem 36.—*Through any point* A, *in the circumference of a circle, to draw a tangent.*

1. Find the centre O of the circle (Problem 35).
2. Draw the radius O A and produce it to B, making A B equal to A O.
3. With centres O and B and any convenient radius greater than B A describe arcs cutting in C.
4. Through A draw C D which shall be a tangent to the circle drawn through A.

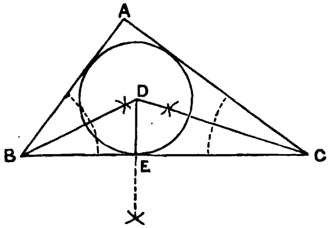


Problem 37.—*To draw a tangent to a circle from any given point* A *outside of the circle.*



1. Find the centre O (Problem 35).
2. From A draw the line A O, which bisect in the point B (Problem 1).
3. With B as centre and B A as radius describe the semicircle, cutting the circumference of the given circle in C.
4. Draw A C which will be the required tangent drawn from A.

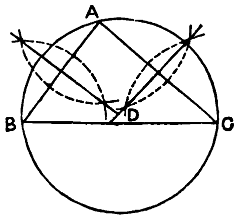
Problem 38.—*To inscribe a circle in a given triangle* A B C.



1. Bisect each of the angles A B C and A C B by the straight lines B D and C D meeting in D (Problem 2).
2. From D let fall D E, a perpendicular to B C (Problem 5).
3. With D as centre and D E as radius inscribe the circle.

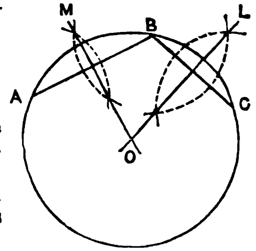
NOTE.—D is called the centre of the triangle.

Problem 39.—*To describe a circle about a given triangle* A B C.



1. Bisect any two sides A B, A C, by perpendiculars meeting in D (Problem 1).
2. With centre D and radius D B or D A or D C, describe the circle, which will pass through the angles.

Problem 40.—*To describe a circle passing through three points* A, B, *and* C, *which are not in a straight line.*

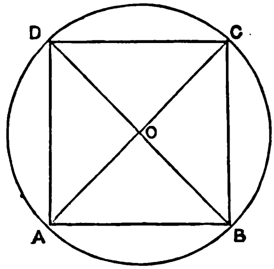


1. Join the points A B and B C.
2. Bisect the lines A B and B C by the perpendiculars M O and L O, intersecting in O (Problem 1).
3. With O as centre and radius O A describe the circle which passes through the given points.

NOTE.—Observe the similarity in working Problems 35 (First Method), 39, and 40.

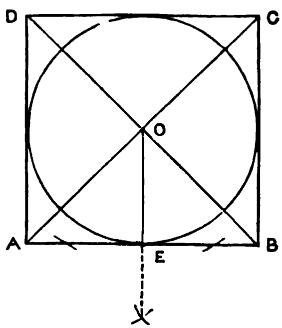
Problem 41.—*To describe a circle about a given square* A B C D.

1. Draw the diagonals A C, D B, intersecting in O.
2. With O as centre and O A as radius describe the circle, which is the one required.



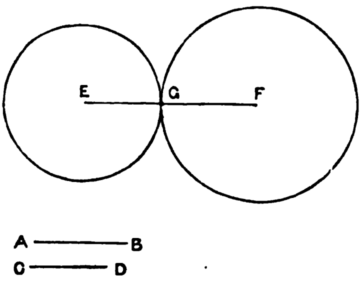
Problem 42.—*To inscribe a circle in a given square* A B C D.

1. Draw the diameters D B and A C intersecting in O.
2. From O drop a perpendicular O E on B A (Problem 5).
3. With O as centre and O E as radius inscribe the circle which is the one required.



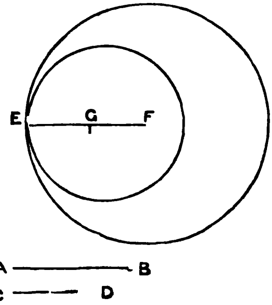
Problem 43.—*To describe two circles of given radii,* A B *and* C D, *which shall touch each other.*

1. Draw the line E F equal to the length of A B and C D added together.
2. With F as centre and radius A B describe the circle, cutting E F in G.
3. With E as centre and C D as radius describe the other circle, which shall touch the former circle in G.



Problem 44.—*To describe two circles of different radii,* A B, C D, *which shall touch each other in a point, one being inscribed.*

1. Draw a line E F equal to the longer radius A B.
2. With F as centre and F E as radius describe the larger circle.
3. From E F cut off E G equal to C D.
4. With G as centre and G E as radius inscribe the circle which will touch the former in E.



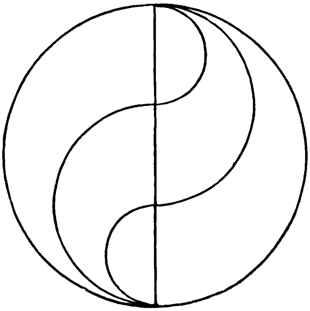
TEST EXERCISES ON THE PRECEDING PROBLEMS.

1. Draw the diameter of a given circle, and divide it into five equal parts.
2. Of an altitude $2\frac{1}{2}$ inches long construct an equilateral triangle, within which inscribe a circle.
3. From a given point outside a circle draw two tangents to the circle.
4. Within a given circle inscribe a square.
5. On a given base A B construct a triangle having angles of 45° and 60° at the base. About this triangle describe a circle.
6. With radii 1 inch and $1\frac{1}{4}$ inch respectively, describe two circles which shall touch each other.
7. Three points, A, B, and C, are given, about $\frac{3}{4}$ inch apart, and not in the same straight line. Describe a circle that shall pass through these points.
8. Within a given rhombus inscribe a circle.

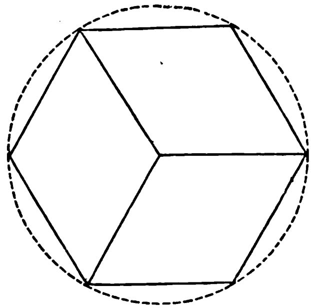
FIGURES TO BE COPIED EXACTLY.

(*Commence in each case by selecting a point as your centre*).

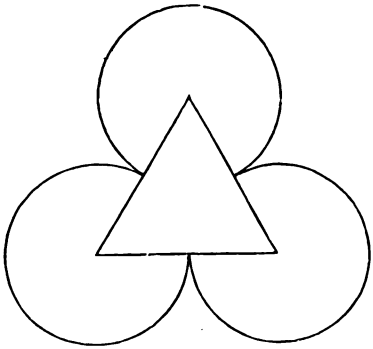
I.



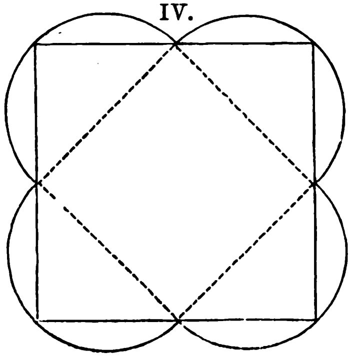
II.



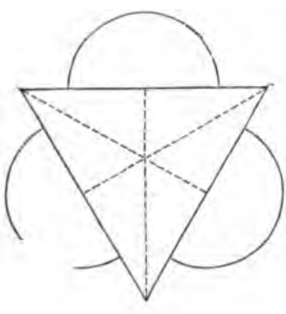
III.



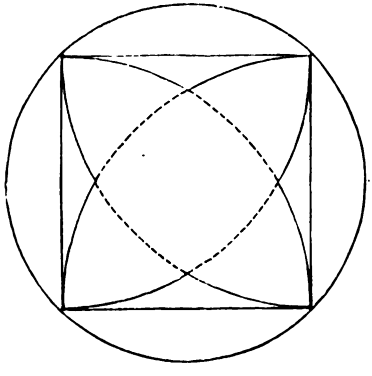
IV.



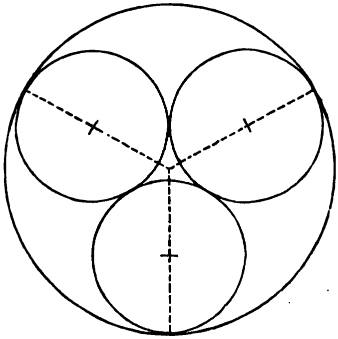
V.



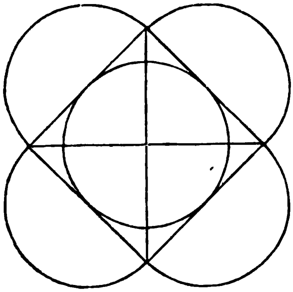
VI.



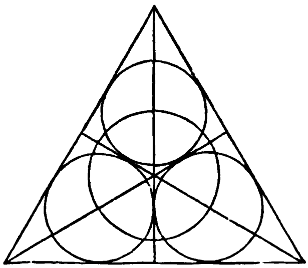
VII.



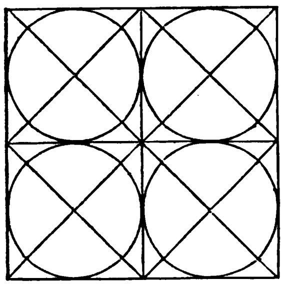
VIII.



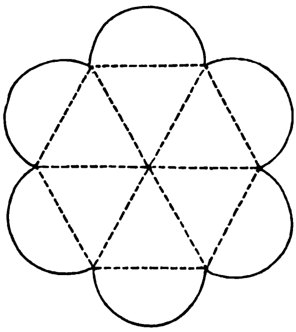
IX.



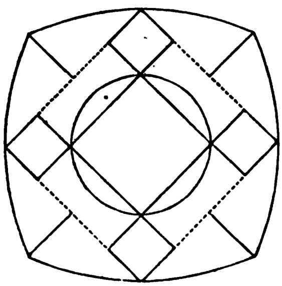
X.



XI.



XII.



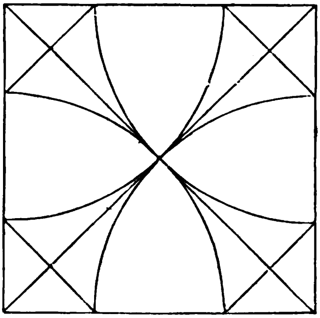
EXAMINATION PAPERS.*

(Set by the Science and Art Department.)

Before beginning any Paper—write (1) your name in full; (2) your age; and (3) name and address of your school. Time allowed for each paper—40 minutes.

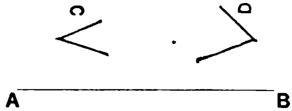
A

1877.

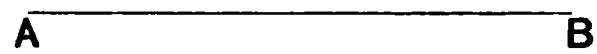


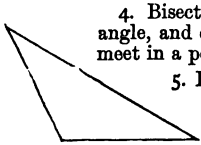
1. Copy the given figure exactly, commencing with the centre.

2. On A B construct a triangle having C and D for its angles.



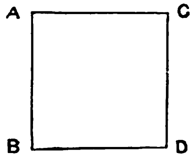
3. Draw a line perpendicular to A B from the point B.





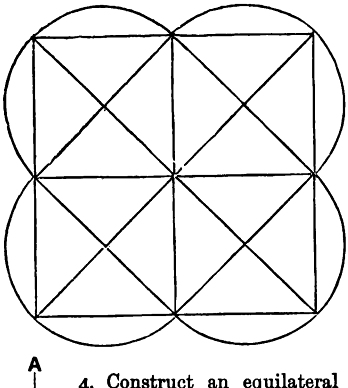
4. Bisect the sides of the given triangle, and draw lines through until they meet in a point.

5. Divide the lines A B and C D into five equal parts, and join the opposite points.



B

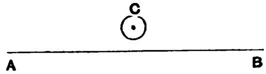
1877.



1. Copy the given figure exactly, commencing with the centre.

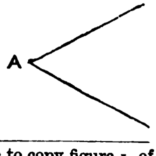
2. Construct a square having A B for one of its diagonals.

3. Draw a line perpendicular to A B from the point C.



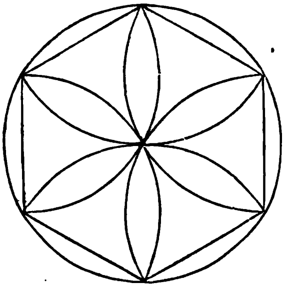
4. Construct an equilateral triangle, having A B for its altitude.

5. Divide the angle at A into four equal parts.



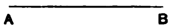
* In working these problems in their drawing books pupils are to copy figure 1, of every paper, exactly the *same size*. The diagrams of the other problems are to be *increased double* the size of those printed.

C 1877.

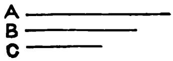


1. Copy the given figure exactly, commencing with the centre.

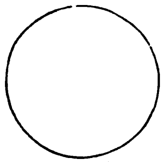
2. On A B construct a triangle with angles equal to those in the given triangle.



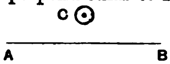
3. Construct a triangle having sides equal to the lines A, B, C.



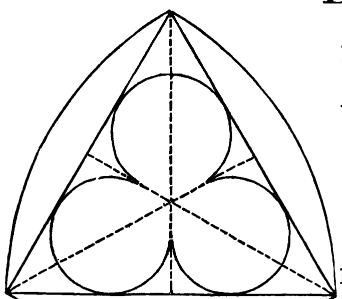
4. Draw the diameter of the given circle, and divide it into six equal parts; and draw the lines so as to touch the circumference of the circle.



5. Draw a perpendicular to A B from C.

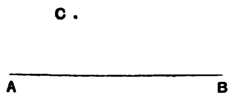


D 1877.

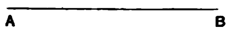


1. Make an exact copy of the given figure, commencing with the centre.

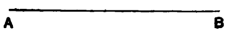
2. Draw a line perpendicular to A B from the point C.



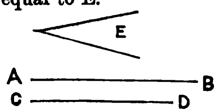
3. Divide A B into six equal parts.



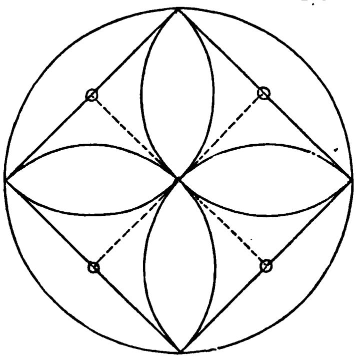
4. Construct an equilateral triangle upon A B. Bisect each side, and draw the lines until they cut one another in the centre.



5. On A B construct a triangle with one side equal to C D, and one angle equal to E.



E 1878.



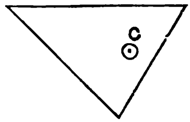
1. Copy the given figure exactly: commence with the circle.

2. Divide the line A B into seven equal parts.

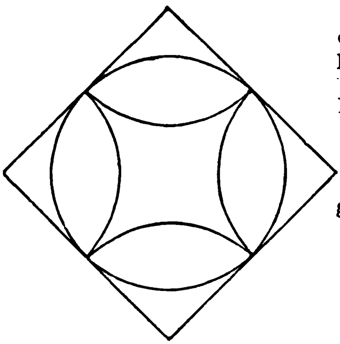
3. Construct a triangle, the sides of which shall be 1½, 2, and 2½ inches respectively.

4. Construct the equilateral triangle of which A B is the altitude.

5. From the point C draw lines perpendicular to each side of the given triangle.



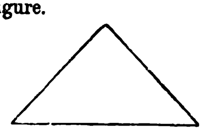
F 1878.



1. Copy the given figure exactly: commence with the square, taking a point as its centre.

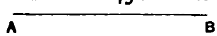
2. Through the given points A and B draw lines that shall be parallel.

3. Bisect an angle and a side of the given figure.

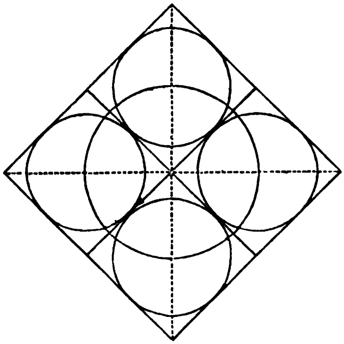


4. Construct an equilateral triangle the side of which shall be 2½ inches.

5. The given line A B is the side of an isosceles triangle; and the angle at A is to be 45°. Construct it.



G 1878.

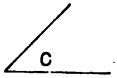


1. Copy the given figure exactly: commence with the square, placing the centre at a point.

2. Draw a line parallel to the given line A B, at a distance of $1\frac{1}{2}$ inches from it.

A B

3. At point A construct an angle half as great as the given angle C.



A B

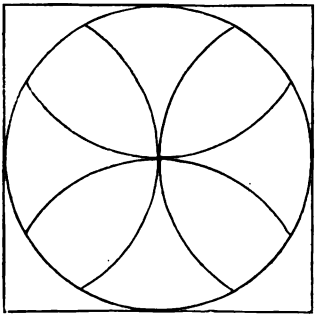
4. A B is the base of an isosceles triangle, and the angle opposite to A B is 90°. Construct the triangle.

A B

5. A B is one side of a square. Construct the figure.

A B

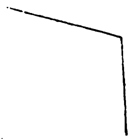
H 1879.



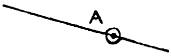
1. Copy the given figure exactly: commence with the square and place its centre at a point.

2. Construct a triangle having a base $2\frac{1}{2}$ inches and angles at the base of 45° and 60° respectively.

3. Divide the given angle into 4 equal angles.



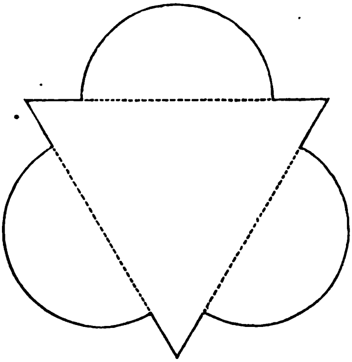
4. At the given point A draw a line perpendicular to the given line.



5. The line A B is one side of a square: complete the square.

I

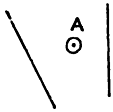
1879.



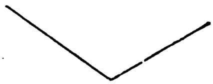
1. Copy the given figure exactly: commence with the equilateral triangle, and place its centre at a point.

2. Construct an equilateral triangle of 2 inches side, and having an angle at point A.

3. From point A draw lines perpendicular to each of the given lines.



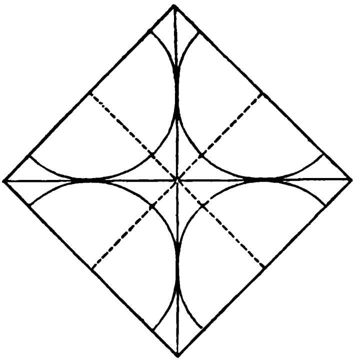
4. Bisect the given angle.



5. With points A and B as centres, describe two equal circles which shall touch each other.

J

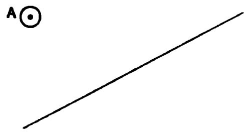
1879.



1. Copy the given figure exactly: commence with the square and place its centre at a point.

2. Construct an isosceles triangle having two equal sides of 2 inches each, and the angle opposite the base of 30°.

3. Through point A draw a line parallel to the given line.



4. Divide the given line into five equal parts.

5. With radii 1 inch and $1\frac{1}{4}$ inch respectively, describe two circles which shall touch each other.

FINIS.

ARITHMETICAL WORKS

PUBLISHED BY

GEORGE PHILIP & SON.

PARRY'S NEW CODE ARITHMETIC, exactly adapted to the New Code as it now stands. It contains over 9,000 Exercises (*chiefly in words*), including many hundred Problems and 640 Examination Papers, rendering Test Cards unnecessary. Standards I. to V., 1d. each (superior edition 2d.); Standard VI., 3d. Answers (*guaranteed correct*) I. to III., 2d. each; IV. to VI., 3d each.

ADVANCED ARITHMETIC for Schools and Colleges. By Thomas W. Piper, late Normal Master and Lecturer in the National Society's Training College, Battersea. Crown 8vo, cloth, pp. 336, price 3s. 6d.

AN ELEMENTARY TREATISE ON ARITHMETIC for Schools and Colleges. By Thomas W. Piper. Crown 8vo, cloth, pp. 160, 1s. 6d.

MENTAL ARITHMETIC, for Pupil Teachers and Students in Training Colleges, containing Rules and Exercises founded on Examination Papers. By Thomas W. Piper. New revised and enlarged edition. Foolscap 8vo, cloth, 2s.

INTRODUCTORY MENTAL ARITHMETIC, for Pupil Teachers and the Advanced Pupils of Middle-Class and Elementary Schools; being a Short Exposition of the uses of Mental Arithmetic, with Illustrative Examples, and a great number of New and Original Exercises. By Thomas W. Piper. Foolscap 8vo, stiff cover, 6d.

MARTIN'S ELEMENTS OF EUCLID, containing the First Six Books, chiefly from the Text of Dr. Simson, with a selection of Geometrical Problems for Solution, to which are added the parts of the Eleventh and Twelfth Books which are usually read at the Universities. By James Martin, Head Master of the Endowed School, Wedgwood Institute, Burslem. Crown 8vo, cloth, 3s. 6d.

MARTIN'S EUCLID, BOOK I., with a selection of Geometrical Problems for Solution. Crown 8vo, cloth, 1s.

MARTIN'S EUCLID, BOOKS I. AND II., with a selection of Geometrical Problems for Solution. Crown 8vo, cloth, 1s. 6d.

MARTIN'S GRADUATED COURSE OF PROBLEMS ON PRACTICAL PLANE AND SOLID GEOMETRY, together with Miscellaneous Exercises in Practical Plane and Solid Geometry, Etymology of Geometrical Terms, &c. By James Martin, author of "Elements of Euclid," &c. Crown 8vo, cloth, 3s. 6d.

WHITWORTH'S EXERCISES IN ALGEBRA, to Simple Equations inclusive; with an Introductory Lesson on Negative Numbers. For the use of Elementary Schools (Government Standards IV., V., and VI.) By W. Allen Whitworth, M.A., Fellow of St. John's College, Cambridge. Foolscap 8vo, stiff cover, 6d.; or bound in cloth, 9d.